

UNIVERSIDADE FEDERAL DO PARANÁ

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INVENTORY REDUCTION FOR RETAIL SUPPLY CHAIN

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## INVENTORY REDUCTION FOR RETAIL SUPPLY CHAIN

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## RESUMO

Nos dias atuais o ambiente de negócios desafiador, com demanda e volatilidade imprevisível, requer uma estratégia de cadeia de suprimentos que gerencie incertezas e riscos da forma adequada. Apesar de modelos de inventário já serem explorados previamente, este artigo busca aplicar estes conceitos em uma situação prática. Este estudo envolve o problema de reposição de inventário aplicando técnicas que são principalmente baseadas em pressupostos e modelagem matemática. O objetivo principal é melhorar o processo de cadeia de suprimentos de varejo levando-se em conta a diferença entre lojas determinando-se os vários níveis de estoque alvo. Através da política de revisão de inventário, implementação de escolha de peças e mínima exposição, é possível não somente promover a redução de inventário como também aumentar os resultados de vendas. A teoria do gerenciamento de inventário descrita na revisão de literatura foi então testada em um caso único, levando-se em conta um departamento em particular em uma das maiores redes de varejo da América Latina.

**Palavras-chave:** Varejo, inventário, estoque seguro, incerteza, distribuição, vendas

## **ABSTRACT**

Today's challenging business environment, with unpredictable demand and volatility, requires a supply chain strategy that handles with uncertainty and risks in the right way. Even though inventory models have been previously explored this paper seeks to apply these concepts on a practical situation. This study involves the inventory replenishment problem applying techniques that are mainly based on mathematical assumptions and modeling. The primary goal is to improve retailer's supply chain processes taking store differences when setting the various target stock levels. Through inventory review policy, picking piece implementation and minimum exposure definition, we were able not only to promote the inventory reduction as well as improve sales results. The inventory management theory from literature review was then tested on a single case study regarding a particular department in one of the largest Latam retail chains.

**Keywords** Retail, inventory, safety stock, risk, uncertainty, distribution, sales

## 1. INTRODUCTION

In a globalized economy, the goal of multinational corporations is to find a more efficient flow of goods and services for corporate or individual consumers. The search for new sources and, the acquisition of increasingly competitive advantages, have been a constant challenge in today's highly competitive world in its marketing, finance, operations, logistics and sourcing. For supply chains, competitive advantage can be obtained through the development of logistics practices and procedures that can optimize order processing, shipping and inventory control.

The main challenge for retail managers is to provide items on the shelf, matching replenishment and demand, for several different products on various stores while overcoming out-of-stocks and excess at the same time (EHRENTHAL et al., 2014). As inventory must be allocated optimally across the stores, regarding the total available inventory, supply chain management is a complex task which requires careful planning and execution (ISHFAQ et al., 2016).

Retail inventory models, when exploited appropriately, lead to significant profits increase (AGRAWALL and SMITH, 2013) once it reduces stock over at stores and ensures customer service level as well as improves the company's assets and capital expenses. Moreover, this inventory represents an important percentage of the fixed costs of a retail business, evidencing the necessity of a study directed toward the search for a model that optimizes these resources.

Although this established approach to inventory control has proved to be very valuable in determining inventory parameters and planning resources,(AASTRUP & KOTZAB, 2010) its value can be questioned in dealing with practical inventory control problems (ZOMERDIJK and DE VRIES; 2003).

This work presents the analysis and results for one of the most traditional retail chains in Latam. In activity for 87 years, the company has more than 1.100 stores and also operates in electronic commerce. The chain sells more than

60.000 items from 2.000 different suppliers holding a major share of trade in toys, chocolates&candies, lingerie, CDs/DVDs, games, health/beauty and household utilities.

An automated inventory replenishment system recommends order quantities to the store manager every order cycle but, system inadequacy arises because inventory management in a retail store is a complex problem involving many constraints and varying product attributes. For the most part, management's understanding of the effect on safety stocks of uncertainty in lead time is based on an approximation of the demand during lead time using the normal distribution.

As having strong backend physical distribution process, inventory management is essential for fulfilling customer orders in a timely and accurate way which has been a recurring challenge for retailers, in order to support store-based operations. In that way, our paper yields some important insights for retail management leading to reduce inventory holding, handling and stock-out cost substantially.

High holding costs of inventory incur from excessive safety stock added by spoiled, expired, or broken during the warehousing process. On the other hand, little safety stock may cause sales lost and, thus, a higher rate of customer turnover. As a result, finding the right balance between high and low safety stock is essential.

The context of our research involves the inventory replenishment problem for products follows with demand rate fluctuation, seasonality, automated ordering system for stores replenishment, lead time variability, periodic delivery, monthly forecast and purchase with occasionally supplier product unavailability. Thus, this paper seeks out to identify inventory procedures and metrics that ensure stores replenishment towards stock reduction. The goal of this paper and its study case is to match demand with supply.

Grounded on inventory literature proceedings the development of this work took four stages: planning the replenishment policy; reviewing stock reference levels; checking the performance indicators and acting to improve the replenishment process. The remainder of this paper is organized as follows. In Section 2 we provide a summary of the methodology. Section 3 introduces the basic literature review for inventory management and retail demand. In Section 4 we present and analyze the study case for inventory reduction on a retail company. Section 5 includes the study case results, discussion and conclusions.

## **2. METODOLOGY**

The research was carried out using a deductive logic starting from the literature review for a better acquaintance with inventory management theory and the current academic debate.

According to Wilson (2014), a deductive approach is concerned with developing a hypothesis based on existing theory, and then designing a research strategy to test the hypothesis. The deductive approach can be explained by means of hypotheses, which can be derived from the propositions of the theory deducing conclusions from premises or propositions (GULATI, 2009). The deduction begins with an expected pattern that is tested against observations, whereas induction begins with observations and seeks to find a pattern within them (BABBIE, 2015). Moreover, deductive reasoning can be explained as reasoning from the general to the particular.

The inventory management theory from literature review was then tested on a single case study regarding a specific department of the retail stores' chain. Eisenhardt (1989) defines the case study approach as a research strategy which focuses on understanding the dynamics presented within single settings through multiple levels of analysis and multiple types of data collection. Study cases on a single exploited situation have been widely used as a source of knowledge in several areas, whether as an example to be followed, a sample of what can happen, or a source of vicarious experience (MARIOTTO et al., 2014).

Even though inventory models have been previously explored, this paper seeks to apply these concepts on a practical case to prove them right or wrong. The following research questions are considered: First, *How to reduce inventory without affecting product availability?* Second, *How to achieve those benefits in a practical situation where business is already running?*

According to the deductive approach, the literature review session formulates a set of hypotheses at the start of the research then relevant research methods are chosen and applied to test the hypotheses. The validity of a research procedure refers to the quality of the research carried out (EISENHARDT, 1989). In this kind of investigation, validity is an attribute that relates to objectivity, to the possibility of repetition of the experiment, to the fact that the research is open to verification by other people and to the capacity for generalization for the case study.

To increase the construct validity of a case study, it is important to establish a clear chain of evidence to allow the readers of the case to reconstruct how the researcher departed from the initial research questions and reached the conclusions (YIN, 2009). The external validity or generalizability of the findings in a case study is a problematic criterion when applied to cases.

Reliability refers to the criterion that research must be such that if other researchers choose to follow the same research procedures, they can achieve the same insights as the initial researcher (DENZIN & LINCOLN, 2000). It is well known that neither a study of a single case nor even of a few cases allow statistical generalizations - that is, extension of the study findings to a population of other cases.

### **3. LITERATURE REVIEW**

In retailing, a variety of products competes to be displayed in the limited shelf space since it has a significant effect on demands (HWANG et al.; 2005). To affect customers' purchasing decisions, retailers properly make decisions about



which products to display and how much to allocate the stocked at the stores (CHEN AND LIN; 2007).

Demand in retailing is known to vary depending on the day of the week and time of year and even along the whole day not evenly distributed within the day (EHRENTHAL et al., 2014). The growing internationalization of production and the shortening of product life cycle, evidenced by market globalization, increased the complexity of logistics operations. While products are sold worldwide, companies seek to centralize their operations by extending distribution networks to meet the market demands (MATTOS and MAGALHAES, 2010) in addition, variability and complexity add risk to the process which may be the result of a wide range of products offered, suppliers and markets.

Besides that, product demands at individual retail stores in a chain often differ significantly, due to local economic conditions, cultural and demographic differences and variations in store format (AGRAWALL and SMITH, 2013). Moving to a shelf-level forecast capability requires the adoption of technology that can scale to potentially hundreds of millions of SKU/location combinations (BAUMANN; 2010).

According to Chopra and Sodhi (2004), the pressure to reduce inventory investments in supply chains increases as competition expands and product variety grows. In order to do so, managers seek for inventories reduction without hurting the provided service level. To compensate the increased risk, which is a fruit of the turbulence of recent periods, companies need to develop programs to mitigate and eliminate them. The great challenge of logistics management is to structure a good responsiveness and flexibility to respond to changes in business strategy and impacts generated by external events, while it earns through lean production.

The reordering process is characterized by the review interval, the determination of the order size, the order costs and the objective function. Two types of review systems are widely used in business and industry. Either

inventory is continuously monitored (continuous review) or inventory is reviewed at regular periodic intervals of length (periodic review). Whether or not to order at a review instant is usually determined by an inventory position that triggers the replenishment order in order to maintain an adequate supply of items to accommodate current and new customers. An order size can either be fixed or variable. The type of replenishment policies with variable order quantities is called order-up-to policies in which the order size is such that the inventory position is increased to an order-up-to the reference level (CHOPRA and MEINDL; 2007).

Safety stock is a function of the cycle service level, the demand uncertainty, the replenishment lead time, and the lead time uncertainty (CHOPRA and SODHI; 2004).

For a fixed-cycle service level, a manager has three levers that affect the safety stock-demand: uncertainty, replenishment lead time, and lead time uncertainty. The safety stock evaluation must consider not only the probability of not having product lack but also the variability of the demand. Each product at each store has a single demand forecast which probability fits Normal statistics distribution, according to Chopra and Meindl (2007). This distribution probability model provides the future probability of occurring “X” events during a certain time interval.

Traditionally, a normal approximation has been used to estimate the relationship between safety stock and demand uncertainty, replenishment lead time, and lead time uncertainty. In this paper, we focus on the flaws in the managerial prescriptions implied by the normal approximation assuming as the best approach using the normal approximation.

Broadly, retailers cannot only increase their profit but also decrease costs by properly managing products allocation and inventory policy review.

#### 4. STUDY CASE

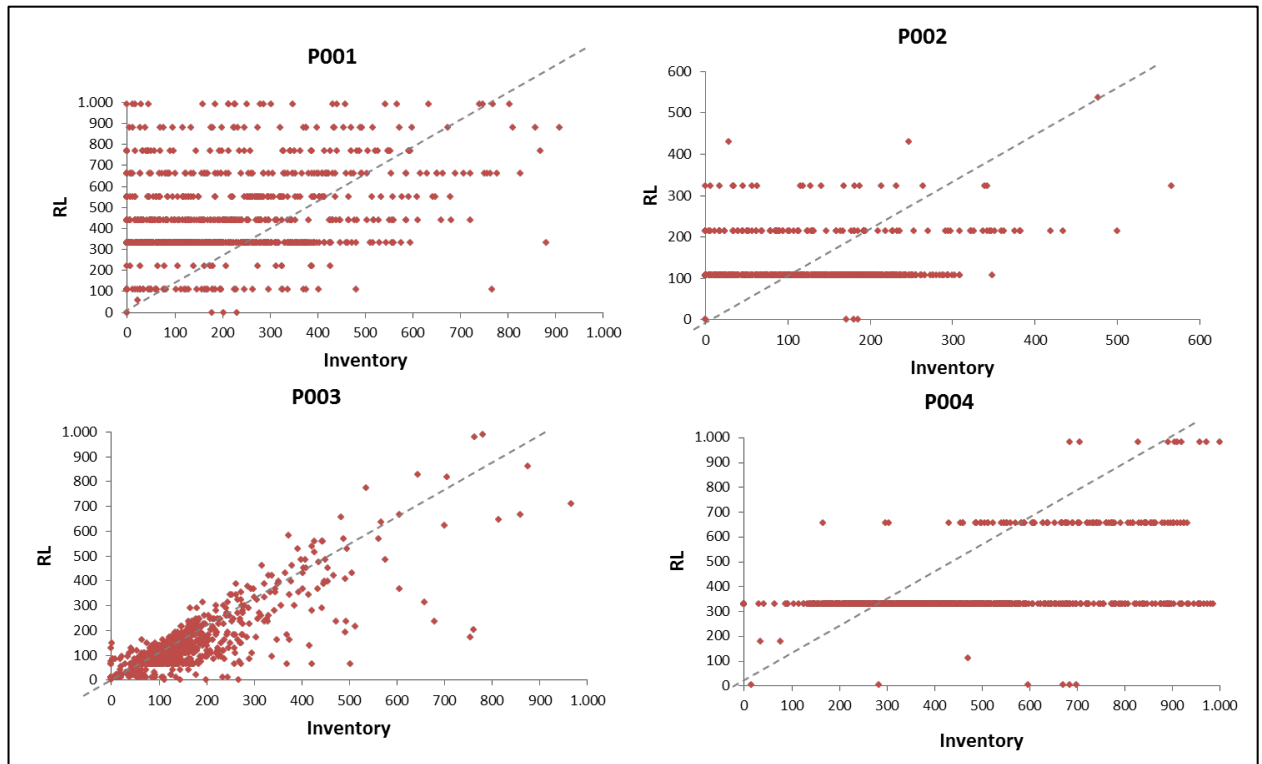
The study case department accounts for R\$23MM in stock, encompassing 8.500k pieces of 1.123 items. Only 35% of those items are active ones – that still under purchase orders - the others are either suspended or canceled items.

Only 1% of the department accounts for “non-sales items” that represents products with not a single unit sold during the last 30 days. The automated ordering system calls for stores replenishment for each product at each store with a pre-settled inventory reference level that generates a replenishment order once it hits 85% of its quantity or if the replenishment size order is at least half unit load.

For the last three years, the department has shown more than 55 days of coverage, which is not a good KPI when compared to other companies and departments on the same store. Besides that, basic items have more than 50% of absence in the warehouses and 20% at the stores. Although it may seem contradictory, those numbers reinforce the inaccurate inventory policy once there is lack of some products and excessive quantity of others.

That leads us to the finding: although the company has plenty of inventories it is not well distributed among the stores. In order to support this idea, we checked the stores' inventory versus the inventory reference level.

Figure 1 shows the distribution of 4 main products across the stores, where each point represents a different store. If the store sits at the main diagonal line between Reference Level and Inventory it means the stock has the exact quantity it should have. If the store is located above the diagonal line, it means there may be some lack of this product but, if the graph shows the store below the diagonal line it represents more inventory than the suggested quantity.



**Figure 1 - Inventory Distribution**

Accordingly, P003 has the best distribution among the stores and P001 needs more units to fulfill the stores. Product P002 and P004 may be negatively influenced by high unit loads that leads replenishment to its full quantity.

This unbalanced distribution leads to increased material purchase as the material may be heavily available at specific stores while others deal with shortage. If the material was equally distributed among the stores the material resource planning would require fewer quantities as we can see from Figure 2. Consequently, once there is not enough budget to acquire the whole required purchase, the warehouse will not receive enough products to fulfill all the stores' inventory. Therefore, stores that perform good sales will go through products shortage without replenishment. Meanwhile, stores with bad sales performance will hold a non-decreasing inventory, enforcing, even more, the unbalanced distribution among stores. These assumptions summarize the department diagnosis as depicted in Figure 3.

This problem could be diminished through reverse logistics but that incurs on a high cost so, it is rather to provide stores with lower quantities of products and, keep some safety stocks at the warehouses, in order to replenish the stores performing the best sales. That ensures the necessary replenishment, avoids unbalanced inventory distribution and reverse distribution costs.

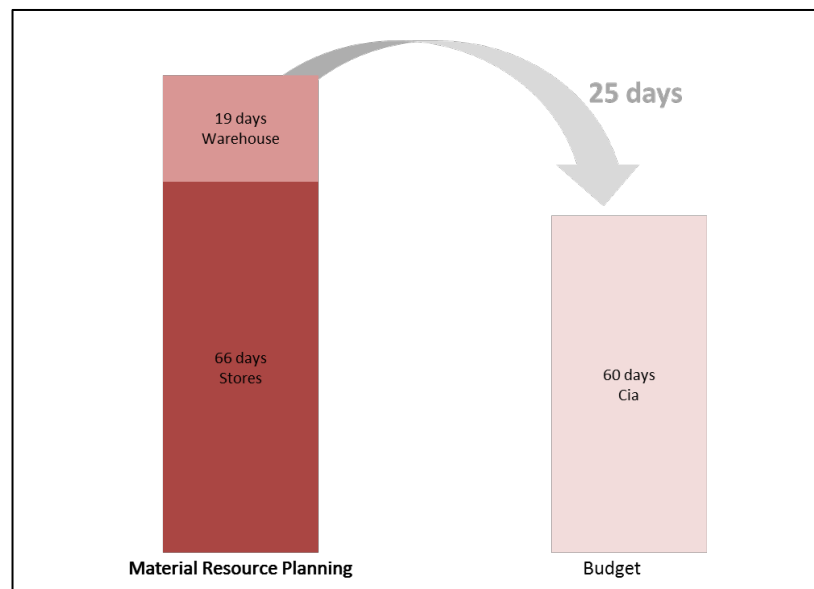


Figure 2 - Inventory coverage: Required X Budget

To quit this vicious cycle the first to do is reduce the inventory reference level at stores so it fits the budget for material resource planning requirement. In order to do so, we investigated the inventory reference level rational.

#### 4.1 Reviewing stock reference levels

The objective of this phase is to achieve a clear insight in the inventory situation and thorough understanding of the cause(s) of the inventory control problem. To that end, the inventory system needs to be described and analyzed. With regard to describing an inventory system, it is important to obtain a comprehensive description of it. This is to ensure a large amount of factors that might play a part in the inventory control problem are included in the description.

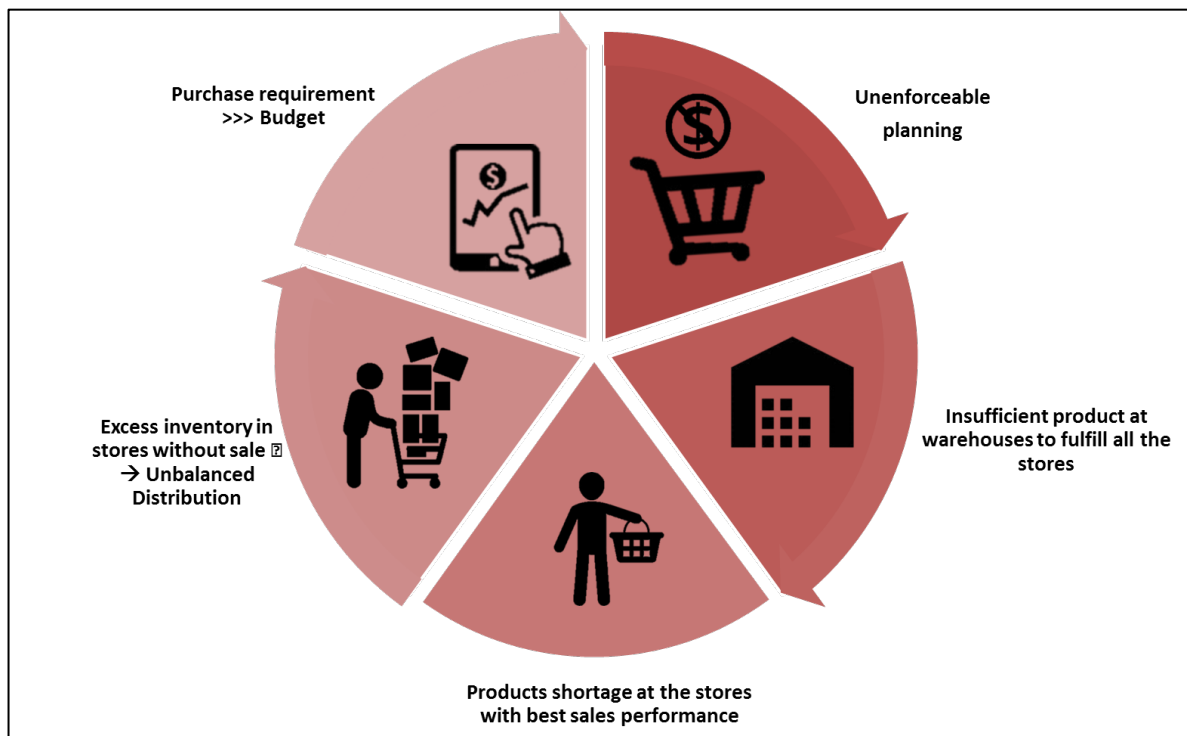


Figure 3 - Diagnosis overview

We obtained detailed sales and replenishment data from all the stores of the retail chain since 2014. For our in-depth analysis, we selected one department that represented a diverse set of values of selling space and turnover and were considered by the retail chain's management to be well operated and representative of the chain.

Inventory reference level at each store has been planned according to:

$$RL = (LT + Coverage) * D + MExp$$

Equation 1 – Inventory Reference level

Where:

RL = Reference Level

LT = Lead Time ( Service Order + Transportation)

Coverage = Number of days planned to ensure product availability

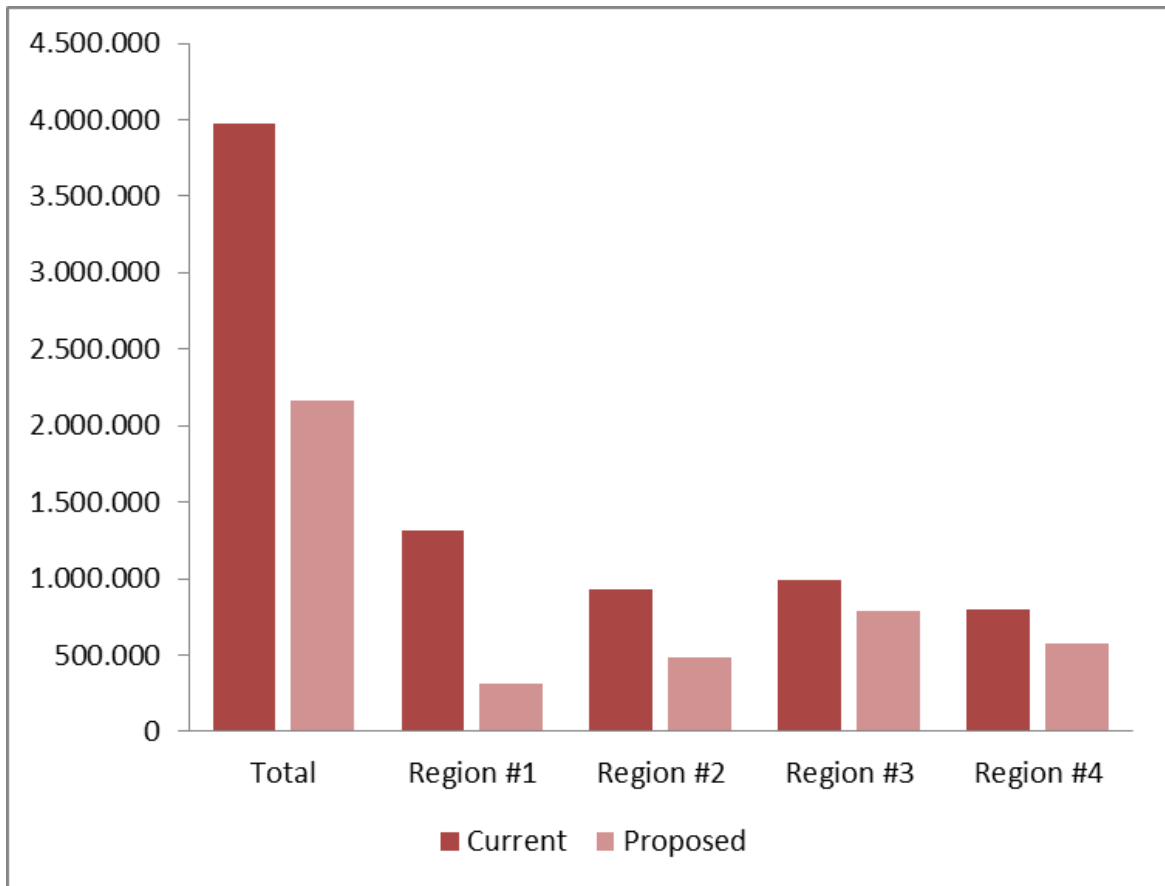
D = Daily Forecast

MExp = Minimum Exposure

The minimum exposure represents the number of units displayed on store based on a fixed shelf facing in order to improve the product assortment and space allocation. Decisions over minimum exposure jointly consider assortment, shelf space space and backroom storage constraints to maximize the retailer's profit or overall sales.

We build a detailed model propounding new product-store safety stock calculation and reorder point definitions by analyzing various combinations of supply chain features such as historical sales distribution, forecast, lead time deviations, replenishment policy. Thus, we suggest replacing the Coverage days for the mathematical accurate safety stock that accounts for the normal cumulative probability of demand regarding lead time and forecast deviations within the proposed Service Level. That means to consider average forecast, lead time, deviations, uncertainty and service level with precise numbers to achieve the most economical inventory instead of considering estimated values of coverage randomly attributed by stock managers.

For each product, the safety stock was then calculated to ensure a certain Service Level. The Service Level indicates the minimum of components demanded that shall be available at the workshop's warehouses. For example, if the Service Level is defined as 90% it means that nine in ten customers demanded must be settled just in time, one in ten can be obtained after some lead time.



**Figure 4 - Inventory Reference Level – pieces**

Then we proposed a new rational for inventory reference level:

$$RL = (LT * D) + SS + MExp$$

$$SS = Z \sqrt{\sigma_D^2 LT + \sigma_{LT}^2 D^2}$$

**Equation 2 – Improved Inventory Reference level**

Where:

RL = Reference Level

LT = Medium Lead Time ( Service Order + Transportation)

$\sigma_{LT}$  = Lead Time deviation

D = Daily Forecast

$\sigma_D$  = Daily Forecast deviation

SS= Safety Stock

Z = Inverse of the cumulative distribution function for the desired Service Level



MExp = Minimum Exposure

This new equation accounted for 40% reduction on the inventory reference level pieces, with different gains over the stores and regions as on Figure 4, and accordingly decreased the coverage days also affecting the required resource material quantities. So, reviewing the inventory Reference Level equation and applying statistical data for uncertainty was the first step to inventory reduction.

The management coefficients model could also be further developed by exploiting different service level for each product category. Working with individual Service Levels guarantee priorities for strategical items while a standard Service Level for the whole company materials could bring excessive inventory.

First, reviewing the list of basic items for the department. This review suggested a new list based on the most representative items regarding sales ticket value, frequency and recency. In that order, we checked for the department top items that ranked the company higher tickets and most frequent ones along the last three months.

After that we checked the impact on inventory quantities for different service levels which resulted on a marginal decrease, as seen on Table 1 so we decided to keep with the original service level.

**Table 1 - Service Level simulation**

	Service Level - current	Service Level - sugestion
Basic Items	95%	90%
Class A items	95%	90%
Class B items	90%	85%
Class C items	80%	80%
<b>Inventory reduction</b>	<b>3%</b>	

## **4.2 Piking piece activities**

Another step to ensure the inventory reduction was reviewing the minimum quantities of stores' replenishment as the company considered providing at least half of the suppliers' unit load on each replenishment.

So, we looked for the average product-store weekly demand to check if the unit load was the best reference for replenishment amount as shown on Figure 5.

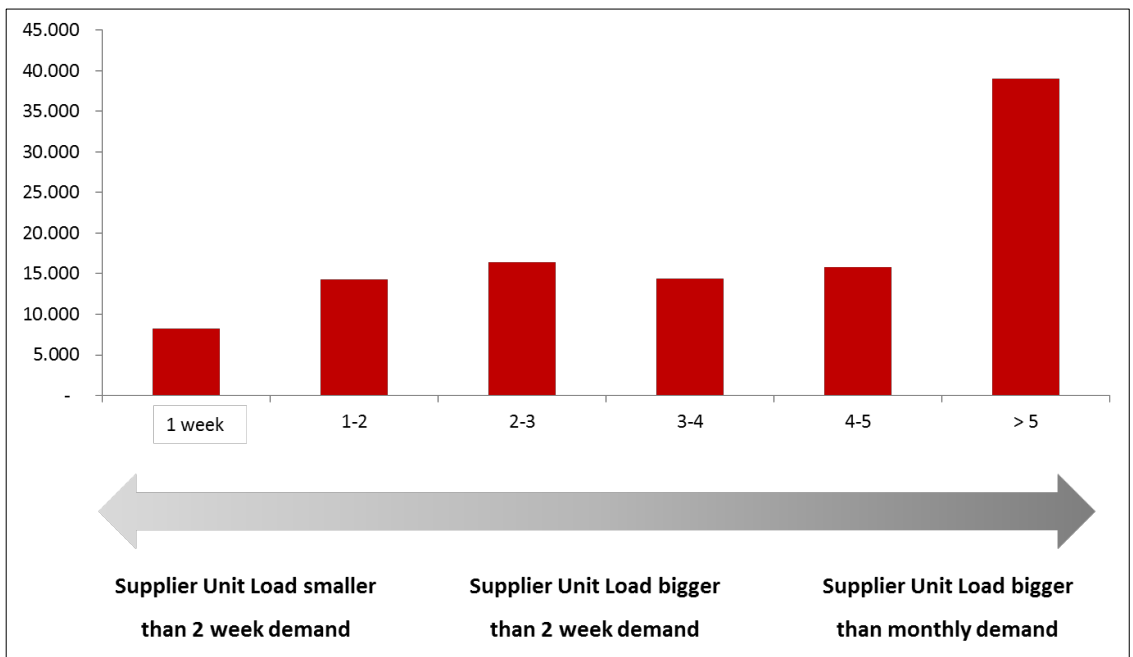
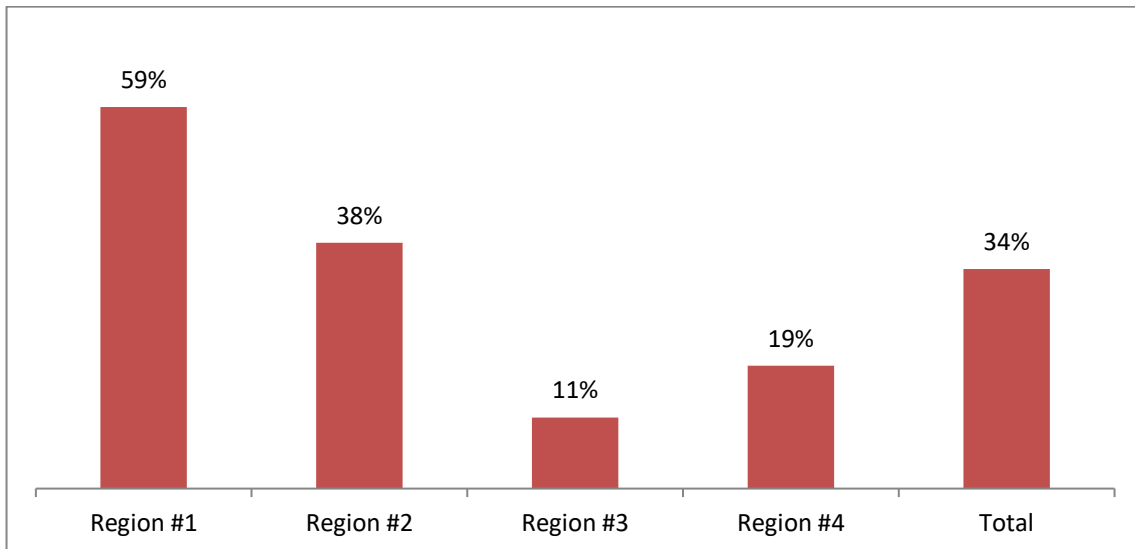


Figure 5 - Relation between Supplier Unit Load and weekly sales distribution (product-store)

As the warehouses already works with the picking piece activity it was only necessary to review the products-store list, ensuring that the picking activity cost pays over the inventory excess at stores increased by supplier unit load.



**Figure 6 – Inventory reduction within Picking Piece implementation**

The best results achieved with this implementation are concentrated on Region#1 mainly because this area holds most of the small stores, with more frequently replenishment, that accounts for the improved results regarding picking piece activities as we can see on Figure 6. Ensuring those stores receive only a fraction of the supplier unit load leads to 59% inventory reduction.

The picking piece activities review - encompassing new items with supplier unit load bigger than the weekly store demand and excluding ones with higher demand combined to small unit loads – led to 34% reduction on stores inventory. Although this detailed activities at the warehouses increases some operational costs, it pays off through inventory investment reduction.

### **4.3 Minimum exposure**

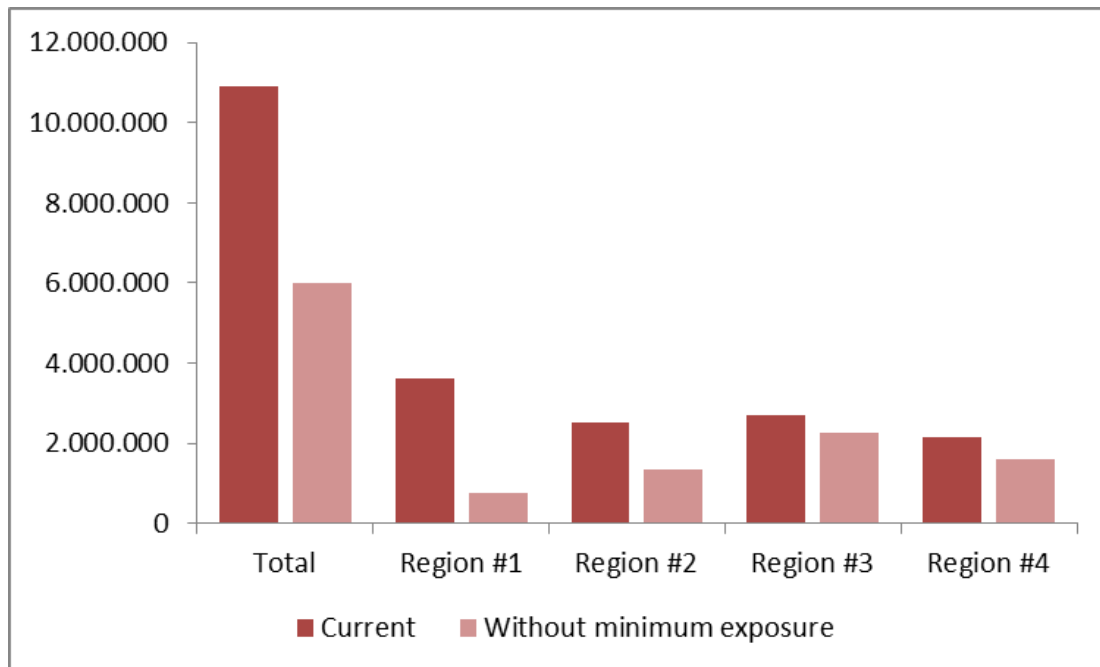
The third step to reduce inventory at stores, without compromising sales, was to ensure the minimum amount of product units on each store as shelf space is one of the most important resources to attract consumers in logistic decisions (YANG and CHEN, 1999).

The products have different forecasts for each store, each one of them requires a minimum exposure quantities that take into account the shelf area, products' size, packaging, cages and organization to make it more attractive to clients.

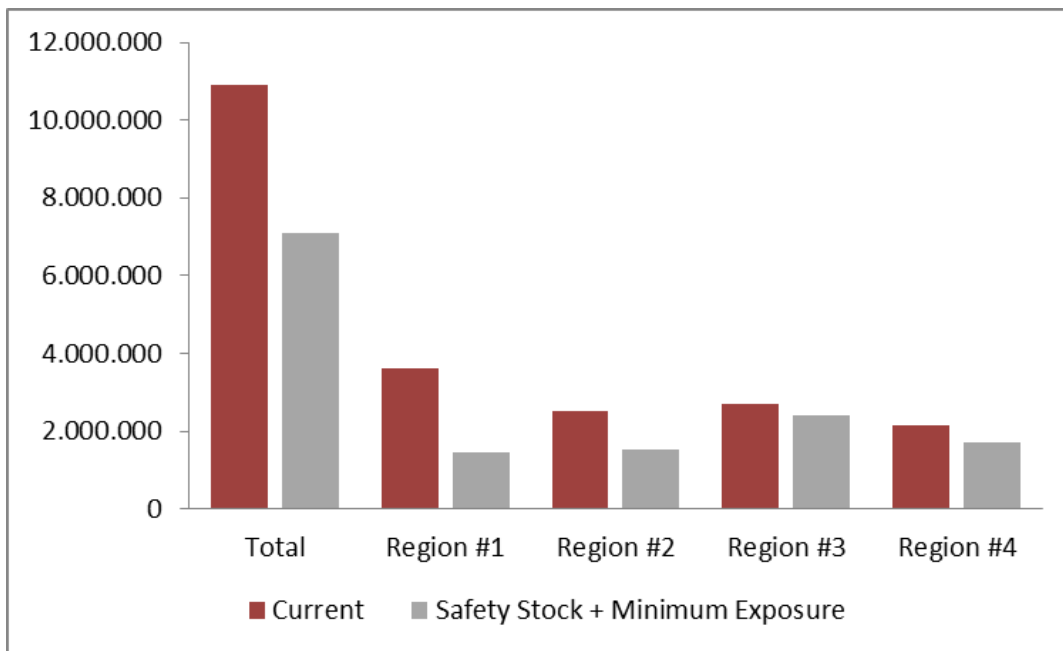
At first, we suggested that the minimum exposure should be the safety stock as seen in Figure 7 but, to ensure the inventory reduction will not affect sales results we came up with a minimum amount that takes into account the category manager suggestion based on marketing guidelines.

So, besides providing the accurate safety stock based on statistic parameters we also suggest stores keep its minimum exposure, as seen on Figure 8, to insure display attractiveness.

The minimum exposure quantities represents than 16% of the total inventory for this department as shown on Figure 8 which is a significant number and indicates some room for improvements.



**Figure 7 - Inventory reduction without minimum exposure**



**Figure 8 - Inventory reduction within minimum exposure review**

As the company runs more than 1.000 stores the minimum exposure quantities of each product was revised based on the store size: extra-small, small, medium and large. Future implementations may also consider the store cluster characteristics to better ensure the right facing and appropriate shelf space for customer references.

## 5. RESULTS

After implementing those three steps, weekly follow up meetings took place to check the new inventory policy accuracy.

As we can see in Figure 9 at the first week after the inventory policy review the total stock cost for the department reduced by 30%. Along the weeks there was a small increase due to the newly purchased items that contributed to warehouses inventory numbers. Anyway, the coverage days proved the reference level review assertiveness.

It is also important to check the sales performance for the study case department as the inventory reduction may affect the customer's perception at

stores. As we considered the minimum exposure amount and suggested the reference level review for at least 90% of service level sales increased, as shown on Figure 10. As sales performance grew and inventory was reduced at the same time we can ensure pre replenishment review for the retail chain was proven effective.

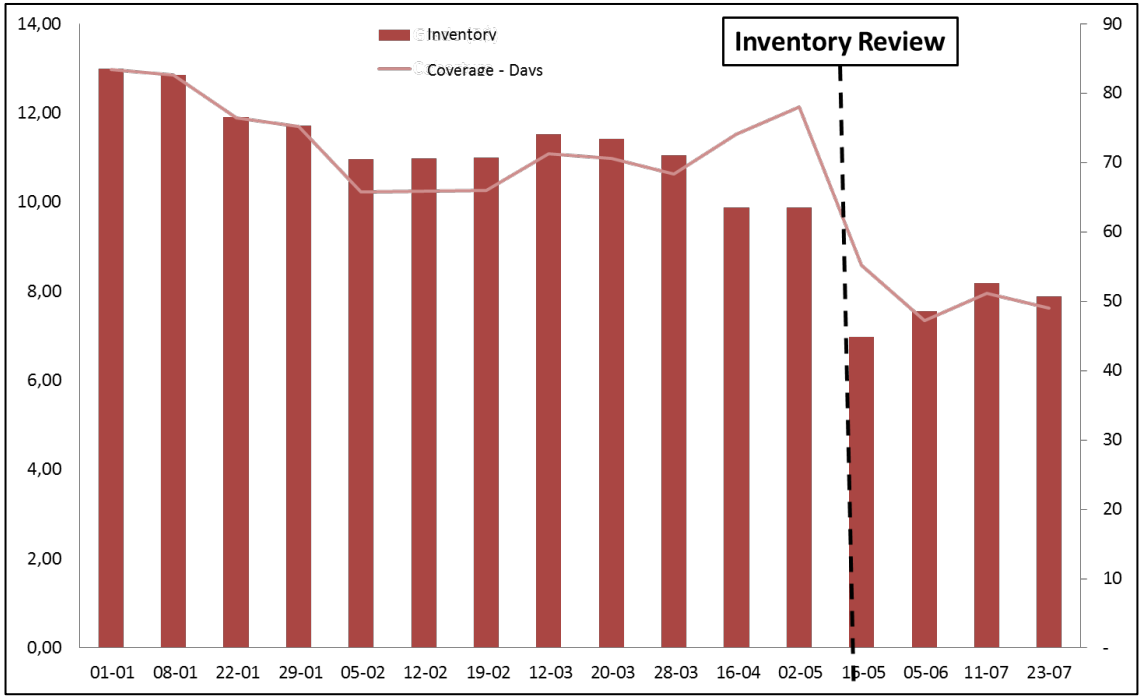
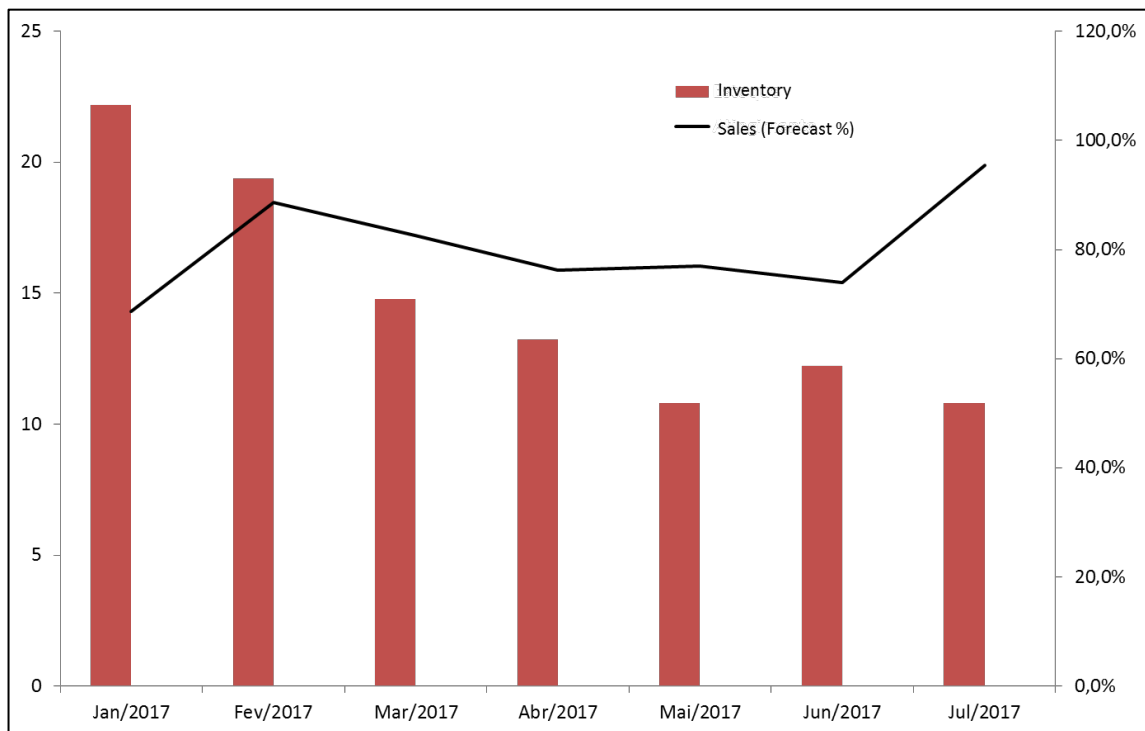


Figure 9 – Weekly Inventory and Coverage

Resizing the inventory at stores not only reduced the material resource planning requirement as it also ensure some quantities at the warehouses to promote replenishment at stores with good sales performance. Accordingly, Figure 11 shows the warehouses inventory coverage improved despite the total coverage days reduction.



**Figure 10 – Monthly Inventory X Sales performance**



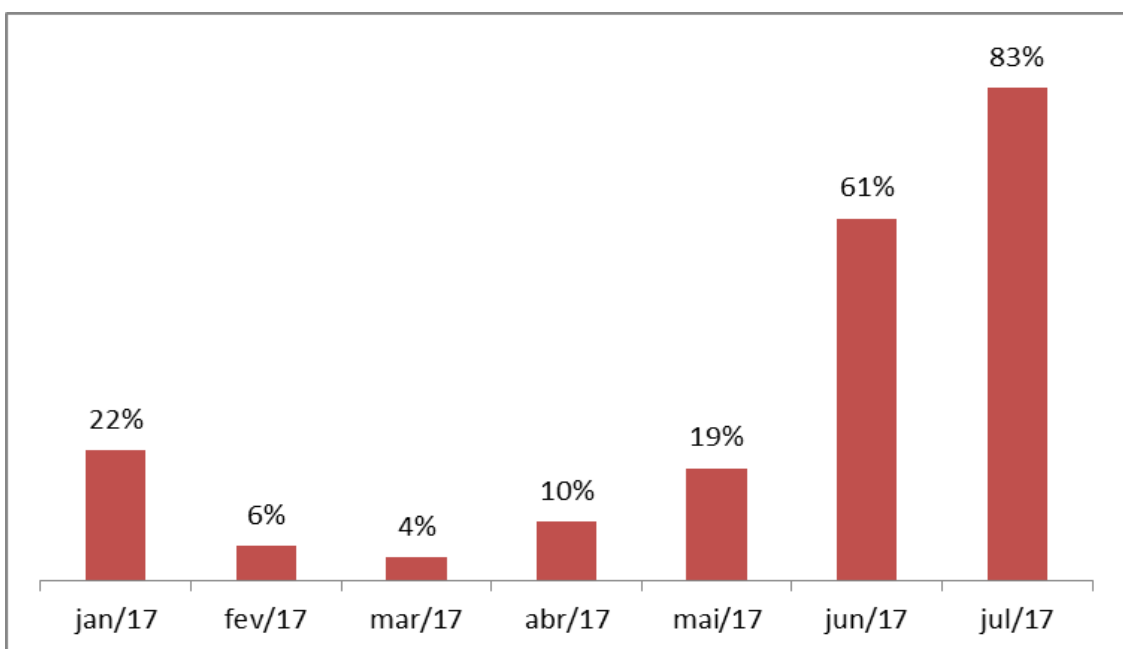
**Figure 11 – Monthly Inventory coverage evolution (days) from January 2017 to July 2017**

This new reference level and inventory review also improved the products distribution among the stores as we can confirm on Figure 12. As previously explained for Figure 1, the bullets (represent stores) placed over the axis diagonal line indicates stores with inventory close to the reference level emphasizing that most of the stores do not have excess neither lack of material.



**Figure 12 - Inventory distribution after the review**

Last, we can check for the assortment purchase evolution as in Figure 13 that shows a significant increase that indicates more accurate usage of the available budget on procurement. As a higher percentage of the assortment is purchased we decrease the lack of products and its availability at stores.



**Figure 13 - Assortment purchase**



## 5.1 Findings

The aim of our study was to provide insights on how to reduce inventory without affecting product availability, in a practical situation, where business is already running. Through inventory review policy, picking piece implementation and minimum exposure definition we were able not only to promote the inventory reduction as well as improve sales result.

Although the performance indicators have shown how accurate the suggested retail replenishment system can be once it considers statistical parameters for demand uncertainty and lead time, instead of estimated days of coverage, there is still room for improvement. Regarding the minimum exposure quantity, the company can apply some planogram techniques to ensure inventory and marketing guidelines. The planogram strategies can provide some guidelines overcoming space constrained decisions of which products to stock (assortment) and how much shelf space to allocate to those products as it is formulated as a constrained optimization problem (HWANG et al.; 2005). That would be extremely helpful to deal with the optimum exposure quantity considering products sales, share, profits, combined sales, inventory, turn, coerture, return on investments and stores organization.

In addition, we also see some room for improvement regarding the sales forecast, as the less accurate it is, the more safety stock is required to ensure a given service level. As most retailers are forecast-driven rather than demand-driven, they tend to make forecasts based upon past sales or shipments instead of direct feed-forward from the marketplace on actual customer requirements. The breakthroughs of Efficient Consumer Response (ECR) and the use of information technology to capture data on demand, directly from the point-of-sale, are now improving the organization's ability to hear the voice of the market and to respond directly to it.

Besides that, we look for replicating these steps on other departments to check the methodology accuracy and effectiveness on seasonal products and irregular demand items.

Finally, we conclude that marketing management has not traditionally recognized the importance of logistics and supply chain management as a key element in gaining sales advantage. However, today's challenging business environment with unpredictable demand and volatility requires a responsive positioning, supported by an expeditiously designed supply chain strategy that handles with uncertainty and risks on the right way to improve customer service, profits and resources usage through the minimum costs.

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